needed light on many points hitherto obscured in doubt."

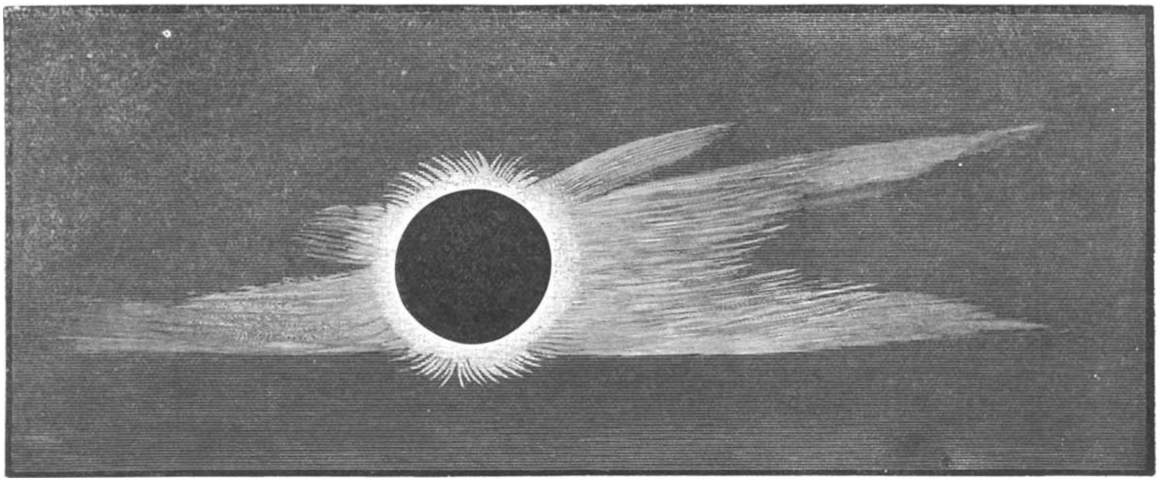

Fig. 3.—Phenomena observed during the total solar eclipse of January 1, 1889 (see Nature, March 7, p. 436).

The similarity of the coronas of 1867 and 1878 was one of the points relied upon when I subsequently discussed (see "Chemistry of the Sun") the possible meteoric origin of many solar phenomena, and pointed out that if this were so, there must be an equatorial ring to produce them. The recent development of the meteoric theory suggests that among the most important observations to be made at future eclipses will be a direct comparison of the spectrum of the corona with the low temperature spectrum of meteoritic dust. It may be that some of the photographs taken during the last eclipse may give us some information on this point, but so far nothing is known.

J. Norman Lockyer.

ON THE GRADUAL RISING OF THE LAND IN SWEDEN.

Although we find in a work by Urban Hjärne, printed in 1702, some remarks on the level of the sea in the Baltic, and the old shore-lines of the island of Gothland, the honour of having for the first time raised this question seriously, and of having subjected it to scientific investigation, belongs to Emanuel Swedenborg, who, in 1719, published a work entitled "On Proofs from Sweden of the Level of the Sea, and the Past World's Strong Flood and Ebb." From the condition of the rocks in West Gothia; from fossils in horizontal chalk and marl beds; from shell-banks situated high above the actual level of the sea; from skeletons of whales and wrecks of ships found far inland; from the structure of the sand-hills and from the round stones found therein; from erratic blocks (or, as Swedenborg calls them, "stones that are spread all over the world"); from giants' bowls; from the shore-lines on Halle and Hunneberg (mountains in West Gothia); from the species of fishes existing in lakes at great elevations; and, finally, from the many proofs of the fall of the sea-level in the Baltic,—from all this, Swedenborg drew the conclusion that the former level of the sea in Sweden was some 400 feet above the present one. These changes he attributed in part to an alteration in the velocity of the earth's rotation and the period of rotation of the moon, whereby the water at the Pole is forced towards the equator. He also assumed that as the Baltic lies at a higher level than the Western Sea, the water therein gradually decreases.

Swedenborg's work, which suggested many points respecting the history of the world that have been hotly debated to the present day, was at first not understood, and continued to be almost ignored by the scientific world. But it was the immediate cause of analogous researches begun by Prof. Anders Celsius, in 1724, along the coast of the Baltic, the results of which he embodied in a paper published, in 1743, in the Proceedings of the Royal Academy of Sciences, entitled "Remarks on the Decrease of the Water in the Baltic, as well as in the Western Sea."

Setting aside all other periods dealt with by Swedenborg, Celsius devotes himself exclusively to the changes in the sea-level which have taken place in historical times. He adduces several examples, tending to show that harbours and roadsteads on our shores have become shallow, and that rocks have gradually risen above sea-level; that ample depth for seine-fishing existed where there is now a shallow; that the appellations "island" and "holm" are frequently used on the coast for uplands surrounded by lowlands, the name "sound" for bights or dry land; that flat rocks at the level of the sea, formerly valuable on account of seals gathering therein, have become valueless by having risen too high above the sea; and that anchors and wrecks have been found in inland peat-bogs. He further compares measurements of the rising of the land extending over 168 years, and comes to the conclusion that at Gefle (on the Baltic), during 100 years, the land rose from 41 to $47\frac{1}{2}$ inches, and, on the opposite side of the Bothnia Sea, from 41 to 50 inches, being an average of 45 inches. Celsius also proves a similar rising on the west coast, and from these facts he infers that the entire Scandinavian peninsula is gradually rising. Celsius further calculates the area of the land thus won from the sea since the days of Pytheas, and finally, for the benefit and instruction of coming generations, has a rock at Löfgrundet, off Gefle, carefully marked, this being the first scientific water-marking of the rising of the land in Sweden. As regards the fall of the sea, Celsius is of opinion that it is partly due to the transformation of water into earth through plants, and partly to the flowing of water into "abysses" in the earth. It may be pointed out that the former theory could hardly be considered absurd at a time when most physicists believed that water could be transformed into earth; and as to the latter, we are still discussing the possibility of water being "absorbed by underlying strata."

Celsius found an ardent supporter in Linnæus, who, returning to Swedenborg's theory, connected the decrease of water with the presence of mussel-shells and *petrificata marina* in strata now situated high above the sea. Linnæus wholly rejected the theory that their presence was due to the Flood. He also held that "endless ages" must have elapsed since the earth began to be inhabited by plants and animals.

The views of these two great naturalists were at first accepted and defended by a number of distinguished scholars. But from 1755 they met with the warmest opposition, especially from the Bishop Johan Browallius, who, from the theological point of view, in a celebrated and learned work refuted and condemned the theories of Swedenborg, Celsius, and Linnæus. When some years later Colonel Carl Fredrik Nordenskiöld presented a paper to the Academy further elucidating the question, four years elapsed before it was published, and even then a "note of apology" for its appearance was appended.

But with the opening of the present century a new controversy arose. The theory of the structure and history of the earth had, during the preceding era, not only become developed into a special science, but students had already, by different opinions on certain fundamental scientific points, become divided into two schools, the followers of which, under a fierce, but to science beneficial, contest, each attempted to prove their views by searching old and collecting new records. Hardly had this strife begun when it became evident of what importance the old question of the rising of the land or the fall of the sea would be for the determination of the matters in dispute. One of the founders of the plutonic school, John Playfair, in 1802 advanced the theory of a connection between the rising of the land in Sweden and the volcanic forces in the interior of the earth, and some years later this view was further developed by the most ardent and gifted champion of plutonism, Leopold von Buch, who himself had had the opportunity during a journey in Scandinavia, 1805-6, by personal observations and by intercourse with Swedish men of science, of learning that at all events most of the observations on which the assumption of a change in the sea-level of the Baltic were founded had been carried out with the greatest care and conscientiousness.

Some of the opposite views, on the contrary, were revived, after a careful study of the literature appertaining thereto, by K. E. A. von Hoff, in an excellent work printed in 1822, entitled "Geschichte der durch Ueberlieferung nachgewiesenen natürlichen Veränderungen der Erdoberfläche"; but it should be added that the views defended in this work were retracted, twelve years later, after a careful discussion of the researches respecting the land rising carried out in 1820-21 by Herr N. Bruncrona, Director of the Swedish Pilot Service, and the observations of Lieut.-Colonel C. P. Hällström, recorded in the Proceedings of the Academy in 1822. Hoff then acknowledged that the theory of the rising of the land formed one of the most important and instructive parts of modern geological science. Hällström, by the way, demonstrated that a considerable rising of the land takes place on the east as well as the west coast of Sweden, that the rising differs in magnitude in various localities, and that no rising exists on the coasts of Halland and Scania in the extreme south.

At this stage of the discussion, the closing word was spoken by the famous English geologist Lyell. He had at first doubted the assertion of the rising of the Scandinavian peninsula, but having, in the summer of 1834, paid a visit to Sweden for the purpose of investigating the question, having examined many of the statements bearing upon it, and having obtained valuable information from Berzelius and others, he published, in the following year, a paper in the Transactions of the Philosophical Society, entitled "On the Proofs of the Gradual Rising of the Land in Certain Parts of Sweden." In this paper Lyell accepts unhesitatingly the views held by the Swedish men of science. He especially points out the theoretically important and instructive fact (already, however, demonstrated by Hällström) that the rising varies much in different localities, and even that in some places in Southern Sweden no rise has taken place within historical times. Lyell's paper remained the final word upon this question for a long time, during which no opposition was raised to the fundamental principle. Efforts, however, were made by fresh measurements on the Swedish coast, to obtain fuller material for research, valuable contributions being rendered by Sven Nilson, P. A. Siljeström, A. Erdmann, Sven Lovén, J. G. Forshammar, G. Lindström, Lord Selkirk, A. G. Nathorst, and others. From these new researches it became evident that it was often difficult to establish harmony between observations made in places very close to each other, a circumstance which indicated that the phenomenon was far more complicated than at first supposed, and which again threw some doubt upon the matter, and caused fresh opposition. Even Lyell himself, in the eleventh edition of his "Principles of Geology," published in 1872, speaks with far less confidence of the land rising; and in a newly published important work the celebrated Austrian Professor, Suess, wholly denies the rising as well as local changes of the shore-lines. The old view of Urban Hjärne is adopted, viz. that the Baltic may be considered a lake, in which the height of the water chiefly depends upon the proportion between the water conveyed into it and the water lost by evaporation and outflow. Space does not permit me to enter further into the ingenious arguments of the eminent Austrian geologist. Hardly had his work left the press before the views advanced were refuted by Dr. Holmström in an elaborate paper, published in the Transactions of the Royal Swedish Academy.

Holmström's researches were begun in 1867 at the instigation of Prof. Otto Torell, so that his paper is founded upon studies extending over a period of thirty years. During that time Dr. Holmström, partly at the expense of the Pilot Service, visited and re-measured most of the old water-marks along the coast of Sweden. New ones have also been cut in the rocks, and for the guidance of future researches the old as well as the new markings have been carefully drawn and described.

The following important synopsis is the result of Dr. Holmström's prolonged studies.

The twenty-four hydrographical rock-marks along the *west* coast of Sweden show that the land in that part has risen about 0·5 centimetre during the last half-century. The rising is incontestable, but varies in different localities, amounting, for instance, at Nordkoster, to almost nothing, but at the Väderö to more than 1 metre in the century.

This result of the west coast researches is very important, inasmuch as no doubt can be entertained that the average water-level there corresponds with that of the North Sea, and that the rising of the land thus demonstrated cannot possibly be caused by a gradual fall of the water in the Baltic.

The two rock-marks on the south coast also indicate a rising during recent years, but as the time between the registration and the cutting of the marks is hardly twenty years, this proof cannot be accepted with certainty.

On the east coast of Sweden, as far as Stockholm, some twenty water-marks have been examined, and here, too, a rising is perceptible in most places, but at Säfvö and Rödskär, and some other places, a *sinking* has taken place during the last twenty years, amounting to 0·7 centimetre a year. This sinking is, however, at all events at Säfvö, as far as can be ascertained from personal observation, of a quite local nature. At Calmar, on the other hand, as already shown by Dr. Siljeström, no change whatever has taken place since the beginning of the century.

From Stockholm northwards there are about thirty water-marks, and here, too, the rising predominates, although it varies often in localities very near each other; but a careful discussion of the observations seems to have established that the rising has been on the decrease during the last century. During the last period it amounted at Stockholm to 0·5 centimetre a year; at Celsius's old water-mark, at Löfgrundet, off Gefle, to 0·9 centimetre; at Chydenius's mark at Ratan to nearly 1 centimetre; at Bergö, on the Finnish side of the Gulf, to 1 centimetre; and at the mark cut by Augustin Ehrensvärd, August 21, 1754, on a rock at Hangö (Finland), to 0·6 centimetre. Therefore, a considerable rising, varying from 0·5 to 1·1 metre per century has taken place in this part of the Baltic.

The above facts, gathered by Dr. Holmström, form the last contribution to our practical knowledge of the old water decrease problem, and many decades must now elapse before fresh data can be obtained for further observations upon these changes in the earth's crust—changes which appear to us to take a long time, but which, geologically reckoned, are very rapid.

If the problem of the land-rising is taken in the same extent in which it was first raised by Swedenborg, it may be divided in two problems, certainly related, but widely separated, and both of pre-eminent importance to the geological history of the earth, viz. (1) the question of the changes of level to which the sea or the hydrosphere of the earth has been subjected in historical times; (2) the question of changes in the level of the sea during the immense length of the geological ages.

As regards the first, it must be considered fully demonstrated, to the student free from preconceived opinions, (1) that in several places along the coast of Sweden, during the lapse of a few generations, a considerable rising of the land has taken place, not only in the Baltic, but also on the west coast; (2) that this rising varies in different localities, and is in some places entirely wanting.

These facts cannot possibly be explained, as some students have attempted, simply by maintaining that the sea-level of the Baltic lies above that of the seas beyond, and that a gradual levelling takes place; as in that case no rising could take place on the west coast. If we, therefore, as is always advisable in natural researches, take the actual observations as basis for our theories, we are compelled to assume that in some places on the Swedish coast a gradual upheaval of the solid fundamental rock really takes place, although some portion of the apparent rising may no doubt be ascribed to a decrease of the water in the Baltic. That such a decrease does occur is probable, but when the student of science refers to it, he should bear in mind that it is only an hypothesis, as yet far from being proved.

Several circumstances seem certainly to speak against the trustworthiness of the observations founded on the water-marks. Prof. P. A. Gadd, for instance, remarks that often there have been found, close to a mark indicating a rising of the land from 3 to 4 feet in a century, trees 300 years old standing close by the water's edge—*i.e.* in places which, when the tree was only a shoot, would have been several feet under water, and this argument has been repeated without contradiction by Lyell, Erdmann, Suess, and others. But it is forgotten, when this is used as an argument against the land-rising theory, that the tree during a period comprising centuries may have sunk through its own weight and through the washing away by rain of the earth at its roots, peculiarities which cannot be unknown to the horticulturist who has planted trees on earthy eminences in parks. Indeed it is self-evident that among the thousands of trees by our shores there must be some which could strike their roots and thrive just in such a spot. Viking mounds, memorial stones, and buildings by the shore might be subjected to similar sinking, the water-marks carved in the solid crystalline rock only being trustworthy as evidence in questions about secular changes in the earth's strata.

Another argument against these observations on the coasts of Scandinavia is that these changes of level, if they do really take place, cannot possibly be confined to this country alone, but must be observable in other parts of the world. But any certain counterpart to the land-rising in Sweden is not known anywhere, not even on the North Sea coast of Norway, nor along the Atlantic border, where foundations of monuments dating from the time of Cæsar still remain intact. The weight of the latter argument is, however, greatly reduced when we bear in mind that observations such as those made in Sweden could not possibly be effected on a coast exposed to the ocean, where, in consequence of the tide, the level of the sea varies diurnally and alters with the direction and force of the wind—changes which so far exceed the land-rising here referred to that they would entirely obscure it. Besides, as regards old buildings, only those built carefully of granite and resting on the solid rock can be taken into account in this discussion. It is, moreover, possible that such an elevation of the land as that in Scandinavia takes place only in districts where the rocks consist of granite or crystalline schist. The Mediterranean being a sea with a mouth far more narrow than that of the Baltic, is unsuitable for the settlement of such questions. On the west coast of Europe, again, the tide is so great that similar observations there would be very difficult. Neither are the sandy shores of Holland and Germany suited for such observations, and the east coast of America has hardly a history long enough for such researches. This applies in a still greater degree to the west coast of America and the coast of Australasia. The volcanic shores of the Pacific Ocean are but little suited for the observation of such changes of the level of the sea. That no rising of the land along the coasts of the oceans has been observed is therefore capable of explanation.

But even accepting the theory that a slow secular disturbance of the level of the shore-line does take place in some localities we are obliged to confess that the geologists at present cannot advance any certain proof of a general change in the level of the sea having occurred in historical times. Any general decrease or increase of the volume of water in the sea in historical times has not been proved. The case is, however, different when it is a question of changes during ages not measured by those of man, but by those of the earth, *i.e.* by the measure of time, which no doubt bears the same proportion to our years and centuries as our terrestrial measures bear to astronomical distances. For in all parts of the globe, as well at the equator as near the Poles, we find rocks which incontestably have, during former geological ages, been formed below the sea, although now lying above it. There is not a shade of doubt about this. And one of the reasons why the geologist has with such great interest studied the question of land-rising in Sweden is that he hopes to derive from the small changes that take place before our eyes an insight into the causes of the great ones. With regret, however, we must confess that our success has yet been very slight. There does not yet exist any satisfactory theory of the origin of the beds of chalk and clay, a thousand feet in thickness, containing fossils of unmistakable sea animals, which are found high up on the slopes of the Alps and far in the interior of high continents.

The marine deposits which are encountered all over the globe high above the present sea-level are stratigraphically of two very different kinds: viz. marine layers which have been greatly disturbed from their original horizontal position, upheaved and thrust up by the side rocks; and marine layers which, lying perfectly horizontally, form the upper strata of the high plateaus, or of the table-mountains.

That the former, after having been deposited as mud below the level of the sea, and afterwards hardened into more or less solid rock, have been dislocated from their original position by mechanical forces, and raised high above the level at which they were formed, pressed together, and thrown above each other,—about this all geologists agree. Formerly the opinion prevailed that the volcanic forces in the interior of the earth had accomplished all this, but we may assume that most geologists are now inclined to seek the cause of the changes indicated in *side pressure*, dependent upon various causes—a theory advocated by me twenty years ago, but then little heeded.

However, this explanation is no longer applicable to marine layers which have not been disturbed in the least degree from their original horizontal position, although they at present form high plateaus several thousand feet in depth and several thousand square kilometres in area. Such formations are, as is generally known, found in all parts of the globe, and from all geological ages. On the west coast of Norway, where no such rising of the land in historical time as in Sweden has been observed, one finds in many places, particularly in the north, terraces or ledges which run perfectly horizontally, irrespective of the geological structure of the coast, for miles along the shore. Since attention was first drawn to these terraces by Urban Hjärne in Sweden, and by Keilhau and Bravais in Norway, they have been the subject of careful study, and of a literature as voluminous as that relating to the land-rising question. No geologist will now venture to deny that we have here before us old shore-lines, indicating that the sea even during the very last geological epoch, but still long before, very long before, historical times, stood far above its present level; whilst the horizontal position observed everywhere, apart from purely local exceptions, appears to contradict the view that this is due to local upheavals. Similar formations are also found in other parts of the world, as for instance at the Cape and the southern part of South America, proving that even there great changes in the level of the sea have taken place since the beginning or middle of the last geological epoch.

Of layers from the Tertiary period we have, in consequence of the erosion during the Glacial age, only traces in Scandinavia; but further north, in Spitzbergen, we find Tertiary strata thousands of feet in thickness. Near the west coast they are much disturbed, but further inland they form almost horizontal strata of sand and clay, here and there containing small coal-seams and schists, rich in splendid fossil remains, bearing witness not only to a magnificent vegetation having once existed in these parts, now ice-covered, but to the fact that the sea at Spitzbergen when they began to form hardly stood higher than at present. When therefore Prof. Nathorst, during one of his expeditions to Spitzbergen, on the highest plateaus of one of these high but horizontal Tertiary beds, found a mighty layer of marine fossils, we obtained proof that during the Tertiary period, geologically speaking so near us, the level of the sea had varied to the extent of several thousand feet. Even here the perfect horizontal position of the strata from Advent Bay by the Ice Fjord across the Storfjord to Franz Joseph's Land, excludes the possibility of these Tertiary marine beds being raised to their present level by volcanic forces. And if we proceed from the Tertiary beds of the Arctic regions to those on which Paris rests, or to those of the United States or of Patagonia, we encounter everywhere proof that the level of the sea has changed many times during the Tertiary period. Analogous observations may be made about the strata from the Trias, the Jura, and the Chalk periods in different parts of the globe. Again, the geologist finds that the level of the sea for some reason or another during those epochs has changed by many thousands of feet, in most places without its being possible to connect this change with the oft-adduced reaction on the earth's crust of the supposed red-hot interior; and the same applies also to layers from the Palæozoic period, from the period during which the rocks of West Gothia, referred to by Swedenborg, were formed.

Independent of all observations on the land-rising in Sweden, and independent of all theories, the fact remains that since the earth became an abode for animals and plants, the level of the sea has changed many times.

But we must confess that up to the present no acceptable theory explaining the *cause* of these changes has been proposed. Some have re-adopted Swedenborg's ancient idea that a change in the rotation of the earth caused a change in the form of the hydrosphere; others have discussed the great influence exercised by heavy mountains on the water-level of the adjacent seas, calculating that under favourable conditions this may amount to a great deal, *i.e.* that the sea-level on coasts that are engirdled by great mountain ridges is several hundred metres above the main level of the ocean in the same latitude; others, again, have sought the explanation in the hypothetical, and to those who are familiar with the Arctic regions wholly arbitrary, assumption, that huge masses of ice are periodically heaped up at one or another of the Poles, and by their attraction cause notable changes in the sea-level; and, finally, some maintain that the rising of the level depends on dust and *débris* being either blown or washed into the sea, and that the sinking depends on water being absorbed by strata in the interior. But to the student reckoning with figures, and who bases his researches on actual observations and not on assumptions, none of these causes explains fully and satisfactorily the great and probably simultaneous changes of the sea-level. To my mind the simplest explanation, and nearest at hand, has never been duly considered.

No doubt this neglect in some degree springs from the still prevailing belief in the quantitative unchangeableness of the heavenly bodies, which with the Aristotelian philosophy has penetrated the intellect of natural philosophers. Kepler, on account of the sun being obscured during three consecutive days in April 1547, most probably by cosmic dust, opposed this principle, declaring expressly, *Cœli materiam esse alterabilem;* but the belief in the old dogma was so little shaken thereby that the scientific ban went forth from more than one quarter against Chladni when he attempted to demonstrate that cosmic matter does really fall upon the earth. Now Chladni's doctrine is everywhere accepted, but even at the present day few geologists will assign to the cosmic matter that falls on the earth an important influence in the formation of new strata. Only a few quantitative studies of the phenomenon itself, and an unprejudiced estimation of the length of the geological epochs, are needed to convince anyone how unjustifiable this is. To my mind it seems fully proved that solid matter, as well as gaseous, and fluid at a temperature above 0°, is daily in great quantities brought to the earth, and that through this fall, and by the masses of *débris* carried by rivers and wind into the sea, the latter must during geological ages have become filled, and its level raised in a manner which would be totally opposed to actual facts, if there were not other causes to counteract it.

Such a cause might be found in the circumstance that, just as fresh matter is hourly brought to the earth by meteors, it steadily loses during its orbit in the solar system some of its gaseous constituents; and the near maintenance of a *status quo* during ages partly depends upon the circumstance that gain and loss balance each other, and partly also upon the gain and loss, during the record of mankind, being so infinitesimally small in proportion to the gaseous and fluid matter surrounding the lithosphere of the earth. But during the geological ages even this "little" may be appreciable: long periods may have passed when the gain has been in excess, which has caused a rise in the volume of the sea; whilst at others the loss has predominated, whereby a gradual fall of the sea-level has taken place.

That the atmosphere sometimes decreases through loss in space it is of course impossible to demonstrate by direct observation; but as we at present know fairly well the forces acting upon a gas or dust molecule in the outer strata of the atmosphere, it seems that we may, from a theoretical point of view, be able to obtain an answer to the question raised here. However, we must, to avoid erroneous and hasty conclusions, here take into consideration so many factors difficult to estimate that the definite answer probably for a long time will give rise to much controversy.

Therefore, although the problem of the rising of the land on the coasts of Sweden and Finland may now be said to have, in the main, been decided, the old question about the diminishing of the sea-level, and that just in the general form in which it was presented by Swedenborg and Linnæus, still remains an unsolved riddle of immense importance to the history of our earth.

A. E. NORDENSKIÖLD.

VARIABLE STARS AND THE CONSTITUTION OF THE SUN.

VARIABLE STARS.—The theory of variable stars set forth by Dr. Brester in a recent essay[1] somewhat resembles those suggested by Zöllner in 1865,[2] and by Dr. Lohse in 1877.[3] Briefly, Zöllner's theory regards variability as being due to the formation of scoriæ on the photospheres of the stars and their subsequent dispersion by the heat due to chemical combinations which take place in virtue of reduced temperature. Dr. Lohse substitutes absorption by the cooled atmospheres of the stars for the reduction of light by scoriæ as in Zöllner's theory, although both agree as to the cause of the removal of the light-obstructing agencies. The theory suggested by Dr. Brester is a little more ambitious than either of these, and, to give a translation of his own statement, "All the phenomena that variable stars present to us are the varied effects of one cause—the intermittent chemical combination at the cool external layers of that which had previously been dissociated by heat" (p. 1). All the explanations are based on the assumption that the stars are stratified spherical agglomerations of gaseous matter, the different layers having different compositions according to their distances from the centre.

Most stars are too hot to allow of the formation of compounds as we know them, but the stars most subject to variability (the red stars) are sufficiently cool, in their outer layers at least, for the formation of such compounds as hydrocarbons. It is in the obstruction of light by these compound vapours that Dr. Brester finds his explanation of variability. He aptly compares the cooling of a star to the running down of a clock-spring, and the intermittent chemical combination to the escapement which regulates it. These changes pass unnoticed in the hottest stars, because the periods elapsing between the coolings is very great, and the combinations formed exert no very great absorbing influence; but in the cooler stars only small changes of temperature are necessary, and the periods are correspondingly short.

Again, although the temperature may be low enough for a combination to take place, the combining substances may be so diluted by other matter that the combination is impossible, just as a mixture of oxygen and hydrogen will not explode if admixed with more than 7½ volumes of air (Bunsen). This condition Dr. Brester describes as a state of *surdissociation.* This state does not last long, because, as the combining molecules get nearer the centre, they get more concentrated, while the substances which prevent their union diminish in proportion. When the combination does take place, there is an "eruption of heat" and the clouds in the outer cool layers are dispersed, the brightness of the star consequently increasing.

So much for the general theory, which Dr. Brester believes to be competent to explain every description of variable star, even such diverse ones as Algol and β Lyræ. He rejects the eclipse explanation of the Algol type on the ground that it is impossible to conceive such large obscure bodies to travel at such an enormous rate, and that it is in contradiction to the recent work of Chandler and Sawyer, showing irregularities in the periods, especially in the case of U Ophiuchi.

Secondary maxima, such as occur in β Lyræ, he believes to be due to double combinations: the first substances which combine by the fall of temperature do not produce sufficient heat to reproduce the first maximum, whereas the next combination does, and these taking place alternately, the β Lyræ type receives explanation. Irregularities in the variability are, according to this theory, due to disturbances brought about by very rapid rotations.

"New stars" are believed by Dr. Brester to be produced by the sudden dispersion of the obscuring clouds which formerly surrounded the star, by heat due to a new chemical combination. On this supposition they must be at a very low temperature before they burst out. It is not easy to understand, however, how any such action as this could raise a star from the ninth to the second magnitude, as was the case with T Coronæ. The spectroscopic difficulty is a still greater one. How the spectrum of a new star just before its disappearance could, on Dr. Brester's view, be like that of a planetary nebula, is not easy to explain. For the present it seems more consistent with the facts to regard "new stars" as being due to the clashing together of two meteor-swarms in space.

In this theory Dr. Brester has attempted too much. Most astronomers are agreed that more than one cause of variability is at work, and it is certainly too much to expect one theory to explain all the various types. Dr. Brester does not seem to be aware that Algol is one of the hottest stars in the heavens, and that a recent photograph by Prof. Pickering shows the spectrum to be the same at maximum as at minimum. If one hot star be variable, why not all? Again, if variability is only manifest in the cooler stars, why does not every cool star give indications of variability? Further, the theory assumes that all variable stars are cooling, whereas Mr. Lockyer's recent work has shown that those of the Mira type are increasing in temperature. Dr. Brester's only objection to Mr. Lockyer's theory of variability is its limited application, but it was not set forth as being universally applicable. If Dr. Brester's theory had been limited to the variables of Group VI. (Vogel's Class III*b*), it would be more reasonable, but even then it would not be easy to understand why all the stars of the group do not exhibit variability.

The Sun.—The second part of the essay attempts to explain the various phenomena presented to us by the

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[1] "Essai d'une Théorie du Soleil et des Étoiles variables," par A. Brester, D.Sc. (Delft: J. Waltman, 1889).

[2] "Photometrische Untersuchungen," p. 252.

[3] *Monatsber. der Akad. der Wissenschaften*, p. 826.